NAVAL POSTGRADUATE SCHOOL
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THESIS

DESIGN AND IMPLEMENTATION OF A NETWORK
OPTIMIZER FOR OFFICER ASSIGNMENT
DURING MOBILIZATION

by

Stephen H. Rapp

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Thesis Advisor: Richard E. Rosenthal

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The new model has been tested at Headquarters, USMC, and is slated for installation in Fall 1988 as a permanent replacement for an existing procedure that has been in use since 1978. The new model improves the turnaround time from days to minutes, reduces computation costs by substantial amounts yearly, and, in tests on FY87 data, resulted in significantly better allocations of the officer pool, according to several measures of effectiveness.

The network model treats officers with similar attributes as supply nodes and billets with similar attributes as demand nodes. Arcs of the

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The model is trebly decomposed with the most time-critical billets optimized first and the least critical last. The three optimizations with appropriate intervening data revisions are conducted in a single model run.

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Design and Implementation of a Network Optimizer for Officer Assignment During Mobilization

by

Stephen H. Rapp
Captain, United States Marine Corps
B.S., United States Naval Academy, 1982

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ABSTRACT

This thesis describes the design and implementation of a large-scale network optimization model for assigning United States Marine Corps officers to billets during mobilization.

The new model has been tested at Headquarters, USMC and is slated for installation in FY 1988 as a permanent replacement for an existing procedure that has been in use since 1978. The new model improves the turnaround time from days to minutes, reduces computation costs by substantial amounts yearly, and, in tests on FY87 data, resulted in significantly better allocations of the officer pool, according to several measures of effectiveness.

The network model treats officers with similar attributes as supply nodes and billets with similar attributes as demand nodes. Arcs of the network represent potential assignments between supplies and demands. Highly detailed information obtained from current USMC databases is used to specify the attributes of the nodes. These attributes are used to decide which officer/billet arcs are allowed in the network. These attributes also govern the arc cost function, which incorporates a hierarchy of objectives: unit fill, billet fit, relocation cost and unit turbulence.

The model is trebly decomposed with the most time-critical billets optimized first and the least critical last. The three optimizations with appropriate intervening data revisions are conducted in a single model run.

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I. INTRODUCTION

A. BACKGROUND

This thesis is concerned with developing computer models to assist the United States Marine Corps (USMC) in the assignment of officers to billets. The Officer Assignment Branch (MMOA) at Headquarters Marine Corps (HQMC) is responsible for this function both in peacetime and during mobilization.

Though conditions and measures of effectiveness vary between peacetime and mobilization, there are several reasons why computer models, particularly optimization models, are useful for assisting with officer assignments at any time. The most important reason is that computer methods can help insure the best possible utilization of the officer pool. Second, they can help MMOA obtain results very quickly and with a minimum of staff. Third, they can help cut relocation costs, as has recently been mandated by Congress.

In peacetime, regular officers receive new assignments about every two-and-a-half years, and reassignments are staggered. Consequently, there is never a large proportion of officers in need of assignments at one time. In contrast, during mobilization, all regular, reserve and retired officers are eligible for immediate assignment.

MMOA successfully assigns 800 officers per month during peacetime. However, during mobilization MMOA will assign upwards of 10,000 officers within a period of a few days. Thereafter assignments will drop but not to the previous peacetime level for at least several weeks.

At the onset of mobilization, the size of the officer corps will increase significantly from its peacetime manning level of approximately 20,000. The actual magnitude of this increase will be related to the level of mobilization. The structure of the force will also be affected, and higher priority will shift to units in need of immediate deployment from units that may stay at homebase longer. Officers with critical military occupation specialties (MOSs), non-deploying women marines (WMs), retired and reserve officers coming on active duty, and reassignment of active duty officers to Fleet Marine Force (FMF) units will all add to the officer flux initially.

During mobilization, the immediate need to respond to a specific threat supercedes the importance to maintain readiness. Shifting emphasis from planning to execution will cause personnel turbulence in both regular and activated reserve units. Combat units that are undermanned need to be filled at the expense of headquarters, base and training commands. In summary, the assignment problem of officers during mobilization differs from the peacetime assignment problem both quantitatively and qualitatively.

B. USMC OBJECTIVES FOR OFFICER ASSIGNMENTS DURING MOBILIZATION

The Marine Corps Officer Assignment Branch has four objectives for any mobilization. The first objective is to maximize fill of billets with acceptable people. The second objective is to maximize the billet fit by assigning the most qualified persons. The third objective is to minimize real dollar transportation costs of moving personnel. The fourth objective is to minimize the resulting unit turbulence, defined as the number of reassignments. These objectives are

generally hierarchical. The first is generally more important than the second, which in turn is generally more important than the third, etc.

C. CURRENT SYSTEM: OSGM

At present, mobilization is handled by a modified version of the Officer Staffing Goal Model (OSGM) [Ref. 1]. The OSGM was developed solely as a decision support model in 1978 to help monitors assigning officers by determining allocation percentages for each officer occupational/grade grouping. The OSGM apparently performs a heuristic procedure based on a sophisticated sorting function.

The OSGM first identifies officers who are available and billets that are presently or soon to be unfilled. It then matches these officers and billets by searching a database which lists five allowable MOS/grade combinations for each billet type. If no available person matches the first combination, the OSGM checks the successive combinations until it fills the billet or has exhausted all possibilities. Billets in units with higher priority (SPL) are filled first.

When the sort is complete, the percentage of billets filled for each billet type is determined. This number then becomes a staffing goal that the monitors will attempt to achieve as they personally conduct the assignment process. During peacetime, this procedure yields attainable lower bounds for filling the Marine Corps' officer billets at a tolerable fit. However, during mobilization, the monitors will not have the time needed to properly compare the OSGM's staffing goals with the Marine Corps's assignment criteria and then manually generate assignment orders.

The OSGM has a subroutine that matches names to staffing goals. This is utilized to generate MAILGRAM

(TM - Western Union) orders for both reassignments and activations of reservists and retirees. Anonymity of peacetime model runs dictates that this subroutine not be used by the monitors carrying out the assignment notifications. However, by including this subroutine and by modifying the OSGM to look at all billets as open and all officers as potential movers, the OSGM can function as a crude assignment model for mobilization.

D. DEFICIENCIES OF THE CURRENT SYSTEM

As presently configured, the OSGM has several significant shortcomings which motivate the development of a separate Mobilization Assignment Model.

Solution quality is a prime consideration. MMOA currently considers the OSGM's assignment output for mobilization problems to be suboptimal. This is primarily because sort-based assignment procedures are heuristic and are not guaranteed to optimize even one criterion.

Timeliness is another important concern. It takes MMOA up to two weeks to prepare and run the OSGM for a single mobilization scenario. The Marine Corps anticipates that it will have only two to three days to determine assignments in a real mobilization. This fact, in conjunction with the need to compare several mobilization scenarios simultaneously makes using the OSGM for mobilization untenable.

Furthermore, since the OSGM was initially set up to take into account tour rotations, training, and many other peacetime factors that are irrelevant in mobilization, much of the detail of OSGM can be disregarded in a mobilization model.

E. GOALS OF NEW SYSTEM

The goals of the model presented in this thesis are:

1. to optimize the following objectives (prioritized in the given order):
   a. maximize fill of billets,
   b. maximize the fit of officers in those billets,
   c. minimize the movement costs of reassigning officers, and
   d. minimize the resulting unit turbulence in the Marine Corps caused by mobilization;
2. to reduce the time required to process assignments during mobilization in order to meet foreseeable time requirements and to give the decision makers the ability to consider force structure impact dependent upon the various scenarios; and
3. to include criteria not directly considered in the existing assignment model:
   a. the addition of Additional Military Occupation Specialties (AMOS's) as an officer attribute,
   b. the ability to quickly alter weighting of the fill, fit, movement cost and turbulence objectives, and
   c. the automatic prevention of the assignment of Women Marine (WM) officers to combat units.

Throughout the rest of this paper the model developed for mobilization will be referred to as the Marine Corps Mobilization Assignment Model (MCMAM) or just simply the model.

F. OVERVIEW OF MODEL

The model developed in this thesis is an application of the classical transportation model of linear programming [e.g., Ref. 2]. The Marine Corps officer pool is partitioned into distinct groupings of officers with similar attributes. These groupings are the supply nodes in the transportation model. Likewise, the officer billets are partitioned into distinct groupings, which constitute the demand nodes in the model.

The attributes used for grouping both the supply and the demand nodes include military occupation specialties, grade, location and sex. Supplies are also distinguished by officer type, and billets are also distinguished by priority of fill.

Allowable officer/billet assignments comprise the model's arcs or decision variables. The output of the model is the optimal flows on these arcs, which represent the number of officers to assign from a particular supply node to a particular demand node. Every potential arc is subjected to an extensive battery of tests which compare the supply node attributes to the demand node attributes. Only arcs that pass all the tests become allowable assignments.

The test battery is also used to determine the arc costs. For each test that is passed by the potential arc, a penalty cost is assessed unless the officer and billet attributes are identical. The more dissimilar, the higher the penalty. The cost of an arc is the weighted sum of these penalties. Fill, fit, movement cost and turbulence are the factors considered in the test battery and penalty assessment; each is assigned a penalty weight to express the importance of each violation.

The objective function of the network model is to minimize the overall system cost, which can be interpreted as overall amount of imperfections in officer assignments as measured by fill, fit, movement cost and turbulence.

Two important aspects of our approach to this problem are the statement of the model as a three-stage hierarchy based on priority of fill, and our separation of this model into three sub-models which are solved sequentially. The highest fill priority is addressed first. Remaining officers are added to the pool available for solution of the next higher priority. This is similarly followed for the lowest priority.

The motives for this separation include not only USMC policy but also reduction of problem size.

G. OVERVIEW OF COMPUTER IMPLEMENTATION

SAS [Ref. 7] computer programs are used to generate supply and demand node lists from raw data files extracted from HQMC databases. These node lists along with files that describe Marine Corps assignment rules and preferences are the basic inputs to the model.

The model's main program then distinguishes the demand nodes' priority levels, generates allowable assignment arcs and arc costs.

After the nodes, arcs and arc costs are generated, and the network is decomposed, the GNET solver [Ref. 4] is called. The optimal assignments are then passed to a report writer which prints the assignments and generates a fill statistic for the first subproblem.

The main program then updates the master supply and demand arrays. All the billets and the officers assigned in the first subproblem are removed from further consideration.

With the first subproblem complete, the main program repeats the cycle of problem generation, network optimization, report writing, and updating the master supply and demand arrays, for medium and low priority demand nodes.

Supplies are also regulated by the officer type attribute. Regular and reserve officers are considered for all billets whereas retired officers are only considered for the lowest staffing priority billets. Therefore, if retired officers are to be considered at all in the mobilization scenario, they would not be considered until the last subproblem of the model.

A breakdown of the model's major parts is shown in Figure 1.1.

H. OVERVIEW OF THE RESULTS

This model running on actual FY87 data has improved fill, fit, personnel moving expenditures and turbulence as compared to output from the OSGM utilizing the same input data. Fill of officers into billets was increased across the Marine Corps by six percent (about twelve hundred officers) while at the same time forcing significantly tighter billet fit requirements. Improvements in movement costs and turbulence probably occurred but cannot be documented, since the OSGM ignores them. These improvements are likely not only because movement costs and turbulence are explicitly considered and used to break ties, but also because secondary MOS's allow more billets to be filled from inside units with the new model. Significant improvements in both CPU and model turnaround time were also realized. Before this work, a model's data preparation and run time required about two weeks. Now, five runs per day are possible.

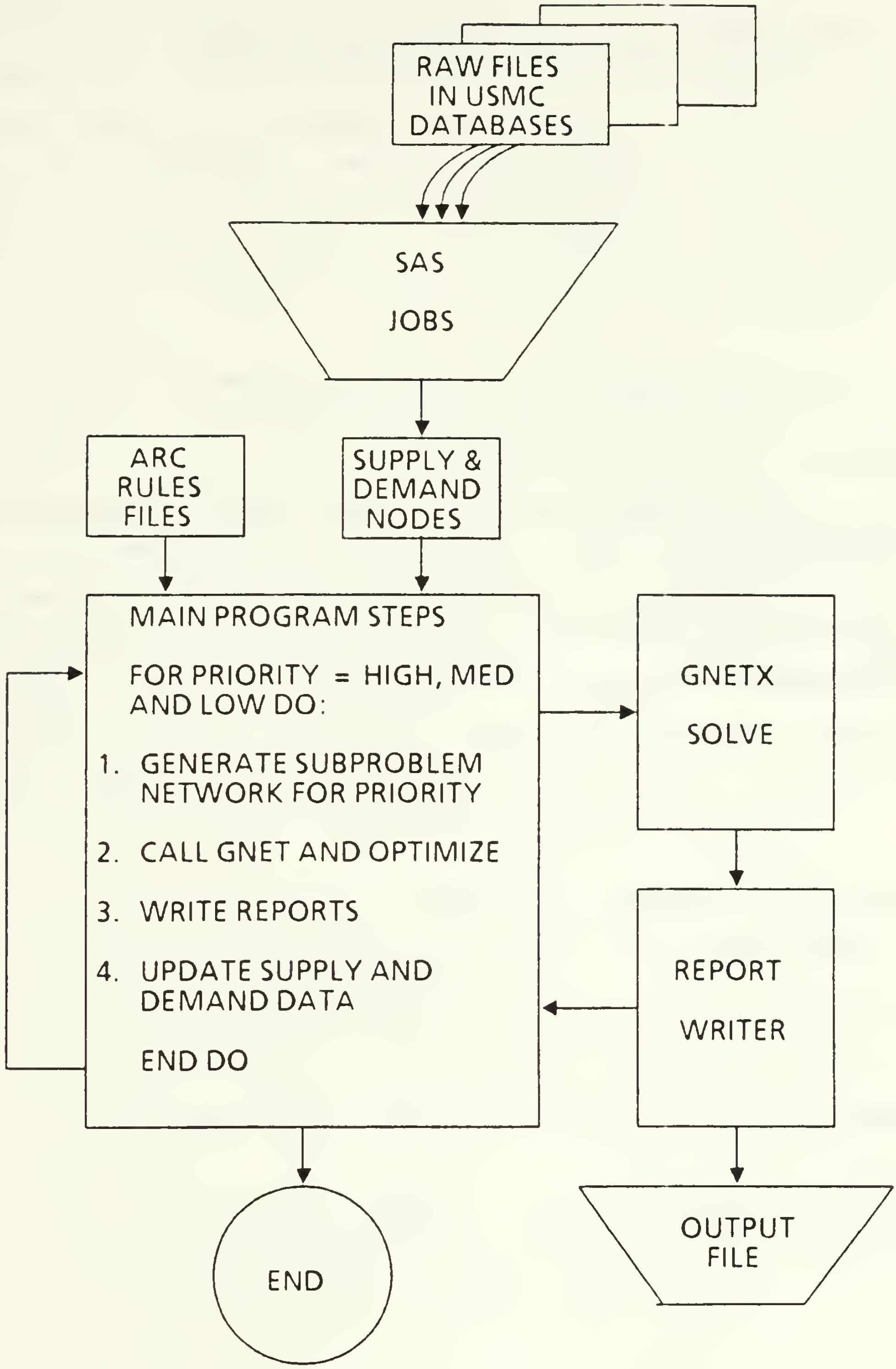

RAW FILES
IN USMC
DATABASES
SAS
JOBS
ARC
RULES
FILES
SUPPLY &
DEMAND
NODES
MAIN PROGRAM STEPS
FOR PRIORITY = HIGH, MED
AND LOW DO:
1. GENERATE SUBPROBLEM
NETWORK FOR PRIORITY
2. CALL GNET AND OPTIMIZE
3. WRITE REPORTS
4. UPDATE SUPPLY AND
DEMAND DATA
END DO
GNETX
SOLVE
REPORT
WRITER
END
OUTPUT
FILE

FIGURE 1.1

I. THESIS OUTLINE

Chapter II introduces terminology and describes the preprocessing of the raw data files from Marine Corps databases, as required to define the nodes and arcs of the network problem. In Chapter III, the Marine Corps assignment rules and other modeling assumptions are presented. The decomposition of the problem into three separate, sequentially linked subproblems and the complete model formulation are also included in Chapter III.

Details on the computer implementation of the model using the GNET network optimizer are given in Chapter IV.

Conclusions and recommendations concerning future improvements are contained in Chapter V. Possible creation of a peacetime model utilizing some of the techniques applied in this thesis is also discussed in Chapter V.

II. - MODEL TERMINOLOGY AND PREPROCESSING

This chapter describes the Marine Corps terminology that is relevant for assignment and the data preprocessing that is required for computer implementation.

A. TERMINOLOGY

Supply nodes represent groups of officers aggregated over the following attributes: **Primary Military Occupation Specialty, Additional Military Occupation Specialty #1, Additional Military Occupation Specialty #2, Grade, Cost Code Center, Officer Type,** and **Sex.** Demand nodes represent officer billets aggregated over the following attributes: **Billet Military Occupation Specialty, Billet Grade, Billet Cost Code Center, Billet Sex Restriction Code,** and **Billet Staffing Precedence Fill Level.** Listed below are descriptions of these attributes:

1. Military Occupation Specialty (**MOS**) - a 4-digit code representing a specific job requirement or personal qualification.
   a. Billet MOS (**BMOS**) - a billet requirement for an officer of that qualification. For example, an infantry officer billet's BMOS is 0302.
   b. Primary MOS (**PMOS**) - each officer's primary job qualification. For example, an infantry officer's PMOS is also 0302.

c. Additional MOS (**AMOS1** or **AMOS2**) - an officer may carry up to two AMOSs in which he is qualified. For example the infantry officer above might carry additional qualification as a logistics officer which is 0402.

There are 131 different officer MOSs in the Marine Corps. Out of the 131 MOSs, there are 3 **generalized officer BMOS's** that are not occupation specific. BMOS 9910 describe billets open for any officer, BMOS 9911 describe billets open for any ground officer and BMOS 9912 describe billets open for any air officer. There are also 30 MOS's that officers cannot carry as a PMOS. These include all occupation specialties requiring graduate school education or other highly specialized training.

2. Grade (**GR**) - the grade of an officer. In mobilization all Warrant Officers (WO1 through CWO4) are grouped together in the same grade (WO). Likewise, all Lieutenants (2nd and 1st) are grouped together in the same grade (LT). Also, all Generals are grouped together in the same grade (GEN).

Generals are included in this model only at the request of MMOA. Since Generals and General Officer billets are matched by hand (literally from the Commandant's desk) we do not propose to use this model to assign Generals in mobilization. However, it is interesting to note that the model forecast actual General Officer assignments from the FY87 data perfectly.

3. Billet Grade (**BGR**) - the desired grade of officer for that billet.

4. Cost Code Center (**CCC**) - a central map location where all the parent Marine Corps units and commands reside. There are sixty-three of these. Deploying units are considered as being either overseas Atlantic or Pacific. The CCC represents the physical location of the officer.

A similar attribute to the CCC that can also represent an officer's location is the Monitor Command Code (**MCC**) which represents every unit and subunit, about two thousand in number.

Since all officers report to their unit's parent command first, a sizeable reduction in geographic data requirements, with no loss of solution quality, is made by using the sixty-three CCC's to represent location rather than the two thousand MCCs.

5. Billet Cost Code Center (**BCCC**) - the billet's cost code center. The BCCC represents the physical location of the billet's unit.
6. Billet Sex Restriction Code (**BSEX**) - unrestricted (noncombat) or restricted (combat).
7. Officer type (**OT**) - there are three types: regular, reserve and retired.
8. Billet Staffing Precedence Fill Priority Level (**SPL**) - **SPL1, SPL3,** and **SPL5**. An SPL indicates the priority each Marine Corps unit has in unit fill and fit. SPL1 requires 100% fill with no MOS substitutions. SPL3 requires 100% fill with limited grade and MOS substitutions. SPL5 units will share equally the remaining officers and can accept recalled retirees. SPL2, SPL4 and SPL6-9 are peacetime SPLs, which are modified during mobilization to SPL1, SPL3 and SPL5, respectively.

All MOS - GR combinations in the Marine Corps are further defined as having an excess, a balance or a shortage of officers. This MOS - GR attribute is derived from the Authorized Strength Report (ASR). For example, if the number of infantry billets for the rank of Major is less than the number of infantry officers at the rank of Major, then the combination of 0302 (Infantry MOS) Majors is considered overmanned (having an excess).

Occupation fields (OCCFLD) are groupings of related MOSs. For example, all pilots are in the same occupation field. The OCCFLD's are exploited in the arc generation module of the computer model.

B. SOURCES OF DATA

The first source of data is the **Wartime Authorized Strength Report (WASR)**, which is a compilation of what each unit needs in personnel strength to accomplish its wartime mission. In some cases the WASR significantly differs from its peacetime counterpart, the ASR. One reason for this difference is the ASR must adhere to congressionally mandated peacetime officer ceilings. Another reason is that staffing precedences for some units change when mobilization occurs. The WASR's billet requirements for officers are broken down by Monitor Command Code (MCC), grade (rank) and the preferred MOS (BMOS).

A second source of data is the **Officer Slate File (OSF)** which carries a complete record of every officer's military qualifications. The data fields in the OSF that are used in assigning officers are: the Name, Grade, Social Security Number (NAGRASSN); the primary MOS (PMOS); any additional MOS's (AMOS); experience codes for each MOS; the MCC of both present

unit and future unit (if decided); the Sex and the Officer type (Regular, Reserve and Retired).

A third source of data is the **MCC Table**. Each MCC in the Marine Corps is listed with its corresponding Cost Code Center (CCC). The MCC Table also includes a code indicating combat units from which women are restricted and it includes each MCC's Staffing Precedence Fill (SPL) level.

A fourth source of data is the **CCC Table**. For purposes of measuring movement costs, the CCC's rather than MCC's are the location attributes for both officers and billets. The mileage between every pair of CCC's is listed in the CCC Table. The 63 CCC's in this table represent all the major geographic locations in the world where Marines are potentially assigned.

A fifth source of data is the **MOS - GR Fill Table**. This table gives what the fill of billets is in the Marine Corps. These fill statistics are given for each MOS - GR combination. Each MOS - GR combination is considered either overmanned (over), undermanned (short) or manned at the proper level (balanced).

C. PREPROCESSING

The model preprocesses the raw data files with SAS [Ref. 7] in the following four phases, discussed later in more detail:

1. Adding to the WASR the SPL and SEX codes for each MCC and then replacing the MCC's in the OSF and WASR with CCC's.
2. Sorting the OSF and WASR by their respective attributes.
3. Aggregating officers and billets over like attributes.
4. Resorting of supply nodes by the AMOSs.

Since officers are considered eligible for BMOS's by either PMOS, AMOS1 or AMOS2, Phase 4 is needed so that the arc generation process does not have to compare every supply node to every demand node. In Phase 2, the revised OSF extract is sorted by PMOS, GR, CCC, OT and SEX. In Phase 3 after aggregation is completed, the supply node file has appended to its nodes their order number. Then in Phase 4, the supply nodes are reordered by AMOS1 and then AMOS2, if AMOS's exist. The other attributes maintain their respective sorting order. The original supply order number becomes a pointer back to the original supply node list for both the AMOS1 and AMOS2 reordered supply nodes. The preprocessing, accomplished through SAS, is illustrated in Figure 2.1. Boxes represent raw data files, ellipses represent SAS-generated data sets and the hopper represents the read entry into the main program.

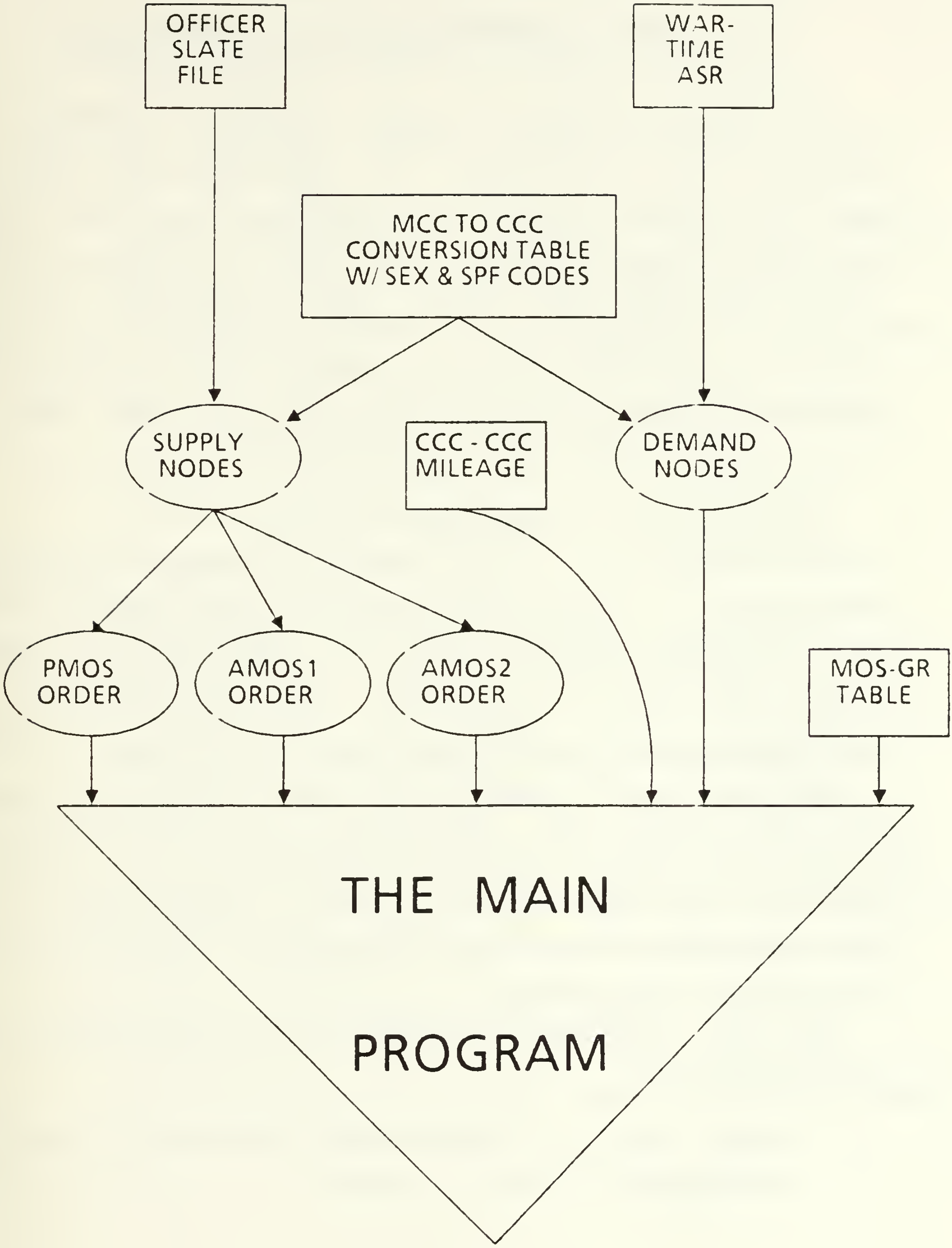

OFFICER
SLATE
FILE
WAR-
TIME
ASR
MCC TO CCC
CONVERSION TABLE
W/ SEX & SPF CODES
SUPPLY
NODES
CCC - CCC
MILEAGE
DEMAND
NODES
PMOS
ORDER
AMOS1
ORDER
AMOS2
ORDER
MOS-GR
TABLE
THE MAIN
PROGRAM

FIGURE 2.1

III. RULES, DECOMPOSITION AND FORMULATION

The first section of this chapter presents the Marine Corps rules which determine whether an assignment arc is allowed to exist in the network. Some of these rules also influence the arc costs. Additional rules-of-thumb that reflect the monitors' actual practice and assist the optimizer are also included. Decomposition of the problem into three separate sequentially-linked transportation problems is explained in the second section. Finally, the complete mathematical formulation is presented.

A. MARINE CORPS ARC GENERATION RULES

The arcs of the model represent allowable assignments. Costs per assignee are based upon a function that compares either the PMOS, AMOS1 or AMOS2 to the BMOS, the GR to the BGR and the supply CCC to the demand CCC. An additional cost increment is added if the officers in the supply node are retired.

Each officer is required to have extensive school training as well as additional on-the-job training to qualify in an MOS. During mobilization, an officer does not have the time to undergo training for a new MOS. Therefore, past training governs the majority of mobilization assignments.

Arcs of the model are generated according to the following rules:

1. Female officers are excluded from units that will be engaged in direct combat.

2. Retired officers are excluded from units that will be engaged in direct combat or sent overseas.
3. To assign an officer outside his MOS is undesirable.
4. To assign an officer outside his OCCFLD is prohibited.
5. To assign an officer to a billet that is not his grade is undesirable but not as undesirable as an MOS substitution within the same OCCFLD.
6. MOS substitutions are not allowed for assignments in SPF1 billets.
7. Regular and reserve officers may fill billets one grade senior to their own grade.
8. Reserve officers may fill billets one grade junior to their own grade.
9. Retired officers may fill billets two grades junior to their retired grade.
10. Assignment of officers whose attributes completely match the billet attributes is most preferred.
11. All other attributes being equal, assigning officers from the nearest CCC is preferred.
12. Officers in short MOS - GR combinations should not be considered for billets outside their MOS.
13. Officers in MOS - GR combinations with surpluses will be considered to fill the generalized officer billets.
14. Officers in balanced and surplus MOS - GR combinations may be considered to fill MOS's that are short of officers but only if they are MOS's inside the same OCCFLD.

15. It is better to fill a billet MOS with a matching PMOS than a matching AMOS.
16. MOS's that officers can carry only as AMOS's will be filled in the same manner as other MOS's.
17. Distance between CCC's is the least important factor in determining cost coefficients for the possible assignments.

B. ADDITIONAL MODEL RULES

1. Listed below are the maximum allowable travel distances for moves (excluding generalized billets):
   a. SPL1 subproblem - 750 miles,
   b. SPL3 subproblem - 1500 miles, and
   c. SPL5 subproblem - 2500 miles.
2. Listed below are the maximum allowable travel distances for moves into generalized billets:
   a. SPL1 subproblem - 0 miles,
   b. SPL3 subproblem - 500 miles, and
   c. SPL5 subproblem - 1000 miles.
3. Filling smaller demands has a slight preference over filling larger demands.

C. HIERARCHICAL SEPARATION BY STAFFING PRECEDENCE

Due to the huge number of feasible assignments (approximately a half million), this model is decomposed into three hierarchical subproblems to facilitate solution. There is one subproblem for each SPL priority. There is no sacrifice of optimality, because the fill and fit of SPL1 units dominates the fill and fit of SPL3 units, which in turn dominates the fill and fit of SPL5 units.

On the supply side, the problem is decomposed on the officer type (OT) attribute. Only regular and reserve officers are eligible for assignments to SPL1 and SPL3 units. Retired officers are brought into the problem only when solving the SPL5 subproblem.

D. COST FUNCTION

The cost or utility function is constructed as a simple additive function. This cost function computes the arc cost for each arc by iteratively comparing the corresponding attributes of the supply and demand nodes for that arc. First, either the PMOS, AMOS1 or AMOS2 of the supply is compared to the BMOS of the demand. If there is an exact MOS fit a cost of zero is determined for the MOS comparison. If it is an allowable MOS substitution a cost increment is derived. Second, the supply GR and the demand BGR are compared. If no grade substitution occurs no cost is added. If there is a grade substitution a cost increment is derived and added to the arc cost. Third, if in the SPL5 subproblem the officer supply being considered has the retired attribute then a penalty cost is added to the previous costs. Fourth, the distance traveled is considered. The supply node CCC is compared to the demand node CCC. If the CCC's differ, a move is required, so a fixed penalty cost is added to the previous costs. Additionally, the mileage between the CCC's is used to determine a variable penalty cost which is also added to the previous costs. Sex is not used in the cost function because there is no preference between male and female when considering non-combat billets. Each incremental cost is weighted. For instance an MOS substitution might cost five times what a grade substitution costs. It is the proper

weighting of each cost that allows combining fill, fit, movement costs and turbulence into a single objective function for each subproblem. Cost code weighting is discussed in further detail in Chapter IV. Once all the incremental costs for the attribute differences between the supply and demand node of an arc are derived and added together, that sum becomes the arc's cost coefficient.

E. FORMULATION OF EACH HIERARCHICAL SUBPROBLEM

The following notation is used for each hierarchical subproblem:

Indices:

- $i \in I$ - supply nodes
- $j \in J$ - demand nodes

Attribute coding for the officer inventory supply nodes:

- $a1_i$ - PMOS
- $a2_i$ - AMOS1
- $a3_i$ - AMOS2
- b_i - GR
- c_i - CCC
- d_i - OT
- e_i - SEX

Attribute coding for the billet demand nodes:

- a'_j - BMOS
- b'_j - BGR
- c'_j - BCCC
- e'_j - BSEX
- f'_j - SPL

Node data:

S_i - number of officers available in the ith supply node. Note that this number may include officers not assigned by a higher priority fill subproblem.

D_j - number of billets in the jth demand node.

Note: The last supply node is an artificial officer node called CLONEMAKER, and the last demand node is an artificial node called UNUSED. The respective values of S_i and D_j for these artificial nodes are established to guarantee that total supply equals total demand. This is needed to use GNET.

$$\sum_{i \in I} S_i = \sum_{j \in J} D_j$$

Cost function:

$$\begin{aligned} C_{ij} = {} & fn(a1_i, a2_i, a3_i, b_i, c_i, d_i; a'_j, b'_j, c'_j) + \\ & p(S_i) + p(a2_i, a3_i; a'_j) + p(d_i) + \\ & p(c_i; c'_j) \end{aligned}$$

where fn is a function of the form:

$$\begin{aligned} & f_{MOS}(a1_i, a2_i, a3_i; a'_j) \\ + \quad & f_{GR}(b_i, d_i; b'_j) \\ + \quad & f_{CCC}(c_i; c'_j) \end{aligned}$$

$fMOS(a1_i, a2_i, a3_i; a'_j)$ is shown below:

		AMOS		
		= BMOS	≅ BMOS	≠ BMOS
PMOS	= BMOS	0	0	0
	≅ BMOS	2	500	500
	≠ BMOS	2	502	N/A

This function shows all the possible matches an officer could make with his MOS's (PMOS and AMOS's) to a BMOS and what the MOS incremental cost is. The equal sign represents a match, the approximately equal sign represents a non-matching but allowable substitution and the not equal sign represents a disallowed substitution.

$$
fGR(b_i, d_i; b'_j) = \begin{cases}
0 & \text{if } b_i = b'_j \\
100 & \text{if } b_i = b'_j - 1 \\
100 & \text{if } b_i = b'_j + 1 \ \& \ d_i = \text{retired} \\
200 & \text{if } b_i = b'_j + 2 \ \& \ d_i = \text{retired} \\
300 & \text{if } b_i = b'_j + 1 \ \& \ d_i = \text{reserve}
\end{cases}
$$

$$
fCCC(c_i; c'_j) = \begin{cases}
0 & \text{if } c_i = c'_j \\
|(\text{mileage}(c_i, c'_j)/100)| & \text{otherwise}
\end{cases}
$$

$p(\ )$ represents an additional penalty derived from the rules.

$$p(S_i) = 0 \quad \text{if} \quad S_i > 1$$
$$ = 1 \quad \text{if} \quad S_i = 1$$

$$p(a2_i, a3_i; a'_j) = 2 \quad \text{if} \quad \text{either } a2_i \text{ or } a3_i \text{ is the supply MOS attribute}$$
$$= 0 \quad \text{otherwise}$$

$$p(d_i) = 0 \quad \text{if} \quad d_i = \text{regular or reserve}$$
$$= 1000 \text{ if} \quad d_i = \text{retired}$$

$$p(c_i; c'_j) = 0 \quad \text{if} \quad c_i = c'_j$$
$$= 5 \quad \text{otherwise}$$

The artificial arc costs for i = CLONEMAKER are:

$c(i,j) = 7000$ if $D_j > 3$
$c(i,j) = 8000$ if $D_j = 2,3$
$c(i,j) = 9000$ if $D_j = 1$

Cost computations for a partially comprehensive set of examples is given below:

1. Assigning CLONEMAKER to a demand node with demand of one has a cost of 9000;
2. Assigning CLONEMAKER to a demand node with demand of two or three has a cost of 8000;
3. Assigning CLONEMAKER to a demand node with demand of four or more has a cost of 7000;
4. Assigning a retired officer with no substitutions has a cost of 1000;
5. Assigning an officer with only an MOS substitution has a cost of 500;

6. Assigning a reserve officer into a billet one grade lower, with no other substitutions has a cost of 300;
7. Assigning a retired officer into a billet two grades lower, with no other substitutions has a cost of 200;
8. Assigning a retired officer into a billet one grade lower, with no other substitutions has a cost of 100;
9. Assigning either a regular, reserve or retired officer substituting into a billet one grade higher, with no other substitutions has a cost of 100;
10. Assigning an officer with a 1000 mile move, with no other substitutions has a cost of 5 + (mileage / 100) = 5 + (1000 / 100) = 15.

Decision Variables:

X_{ij} - the number of officers to be assigned from node i to billets in node j.

Constraints:

$$\sum_{j \in J} X_{ij} = S_i \quad \text{for } i \in I$$

No more officers can be assigned from a supply node than are available at that supply node.

$$\sum_{i \in I} X_{ij} = D_j \quad \text{for } j \in J$$

The demand of billets must be met at each demand node.

$X_{ij} \geq 0$ for $i \in I$ and $j \in J$

All flows (assignments of officers) are non-negative. In fact, the results of the optimization are guaranteed to be integers if S_i and D_j are integer [e.g., Refs. 2 and 3].

Objective function:

$$\text{Minimize} \sum_{i \in I} \sum_{j \in J} (C_{ij} * X_{ij})$$

The objective function simply states that the objective of this model is to minimize the overall cost of assignments throughout the entire Marine Corps.

An example of a simple node-arc diagram that could represent a plausible subset of the mobilization problem is given in Figure 3.1 on page 34. Listed below are some arc cost examples for arcs in Figure 3.1 as derived from this model's formulation:

1. Supply node 1 to demand node 1 - no substitutions, AMOS usage penalty. Arc cost = 2;
2. Supply node 3 to demand node 2 - CCC substitution, move of 500 miles. Arc cost = (500 / 100) + 5 = 10;
3. Supply node 2 to demand node 5 - GR substitution, 1 grade up. Arc cost = 100; and
4. Supply node 2 to demand node 3 - no substitutions, no penalties. Arc cost = 0.

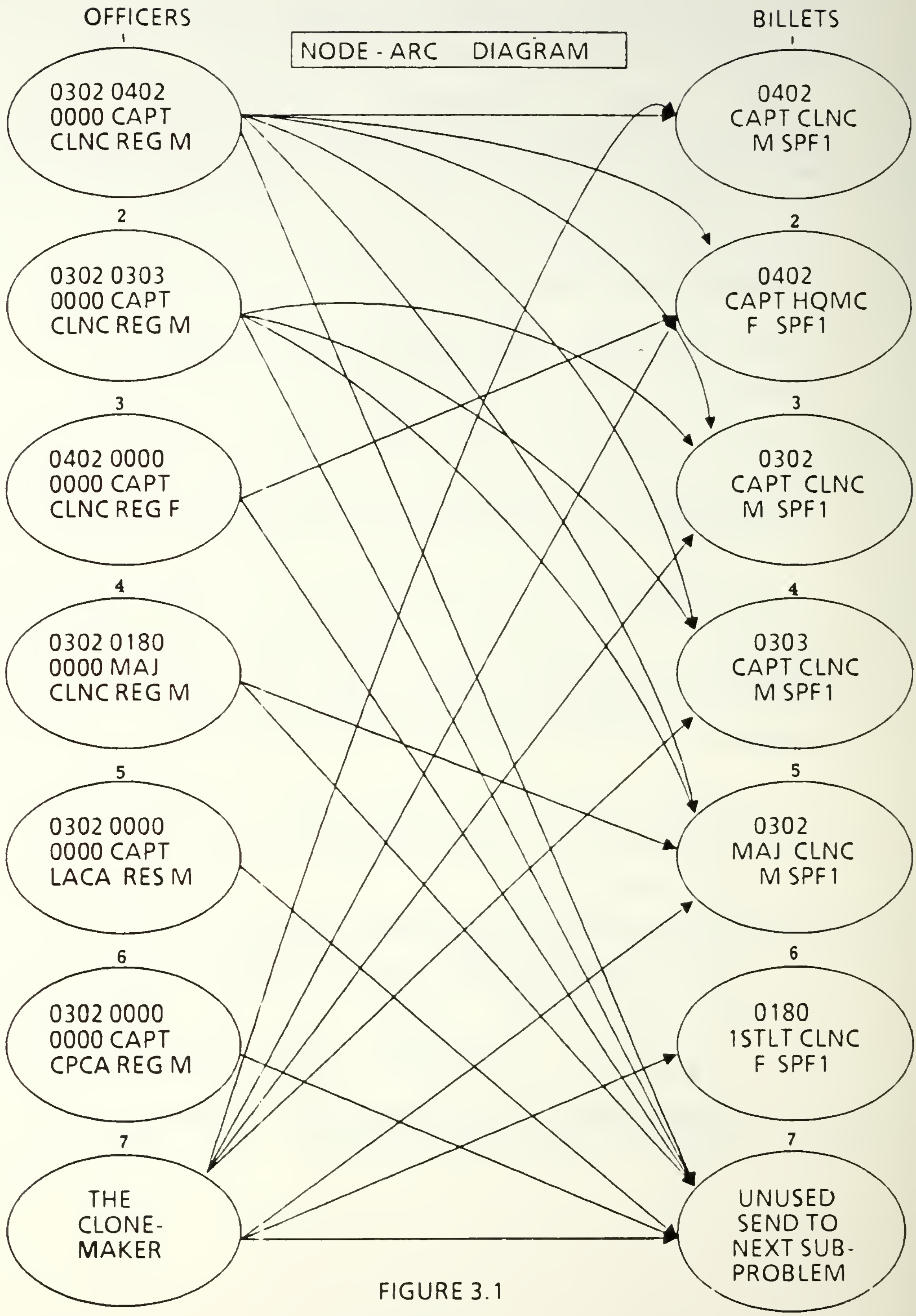

OFFICERS
NODE - ARC DIAGRAM
BILLETS
1
0302 0402
0000 CAPT
CLNC REG M
2
0302 0303
0000 CAPT
CLNC REG M
3
0402 0000
0000 CAPT
CLNC REG F
4
0302 0180
0000 MAJ
CLNC REG M
5
0302 0000
0000 CAPT
LACA RES M
6
0302 0000
0000 CAPT
CPCA REG M
7
THE
CLONE-
MAKER
1
0402
CAPT CLNC
M SPF1
2
0402
CAPT HQMC
F SPF1
3
0302
CAPT CLNC
M SPF1
4
0303
CAPT CLNC
M SPF1
5
0302
MAJ CLNC
M SPF1
6
0180
1STLT CLNC
F SPF1
7
UNUSED
SEND TO
NEXT SUB-
PROBLEM

FIGURE 3.1

IV. COMPUTER IMPLEMENTATION AND RESULTS

A FORTRAN 77 computer program was written to drive the GNET network solver [Ref. 4] to obtain optimal solutions for the mobilization problem. Using real data obtained from the MMOA at HQMC, the completed model was run on an IBM 3033AP using the CP/CMS time sharing system. The same model, but using smaller arrays, ran successfully on an IBM PC/AT utilizing the Ryan-McFarlane FORTRAN compiler. Approximately, three-and-a-half megabytes of RAM is needed to run the full model.

A. DEVELOPMENT AND IMPLEMENTATION HISTORY

The initial prototype model was written in GAMS/MINOS [Ref. 5] and run on both an IBM 3033AP and an IBM PC/AT. Two types of objective functions, one linear and one nonlinear, were tested with GAMS/MINOS. The nonlinear objective function explicitly modeled the Marine Corps' desire to spread the shortages and overages of the different types of officers evenly across the Marine Corps. Although aesthetically pleasing, this formulation used too much CPU time. The linear objective function tested in GAMS/MINOS followed the format of the arc costs described in the previous chapter. The conversion to a linear objective function resulted in tremendous savings in CPU time while maintaining high-quality assignments.

Generally, GAMS/MINOS helped in resolving the basic modeling question of how to accurately reflect assignment complexities mathematically without sacrificing computational speed.

A second prototype model was written in NETSOLVE, a PC package that has an algorithm for transportation problems [Ref. 6]. NETSOLVE showed that reflecting the Marine Corps' multi-criteria assignment preferences as transportation model costs yielded superior assignments at a tremendous savings in time. In addition, NETSOLVE showed that by merely altering these costs without having to change the supply and demand information, a myriad of mobilization scenarios could be run in short order. The decision to go ahead with a full-scale implementation of the mobilization problem utilizing the classical transportation model was then made. However, neither GAMS/MINOS nor NETSOLVE was considered a practical tool for the large-scale optimization required by the full model.

GNET [Ref. 4] was chosen as the optimization package to implement a solution for the full scale model. GNETX, which is the FORTRAN subroutine variant of GNET was the version implemented. The use of GNETX allows the bypassing of a front-end (SHARE format) reader which saves processing time. In addition, since GNETX is a subroutine, multiple calls may be made to it. The main program and report writer were written in FORTRAN.

Throughout the entire development of this model, MMOA was completely involved in validation and guidance. Each modeling and computer implementation phase was conducted under their supervision. A sincere effort has been made to keep the conceptual design of this model as realistic as possible. However, since results tend to generate unanticipated questions and new requests, the need for changes in the modeling and the computer implementation are inevitable. The model has therefore been developed to allow easy change. The software design is completely modular so that even if

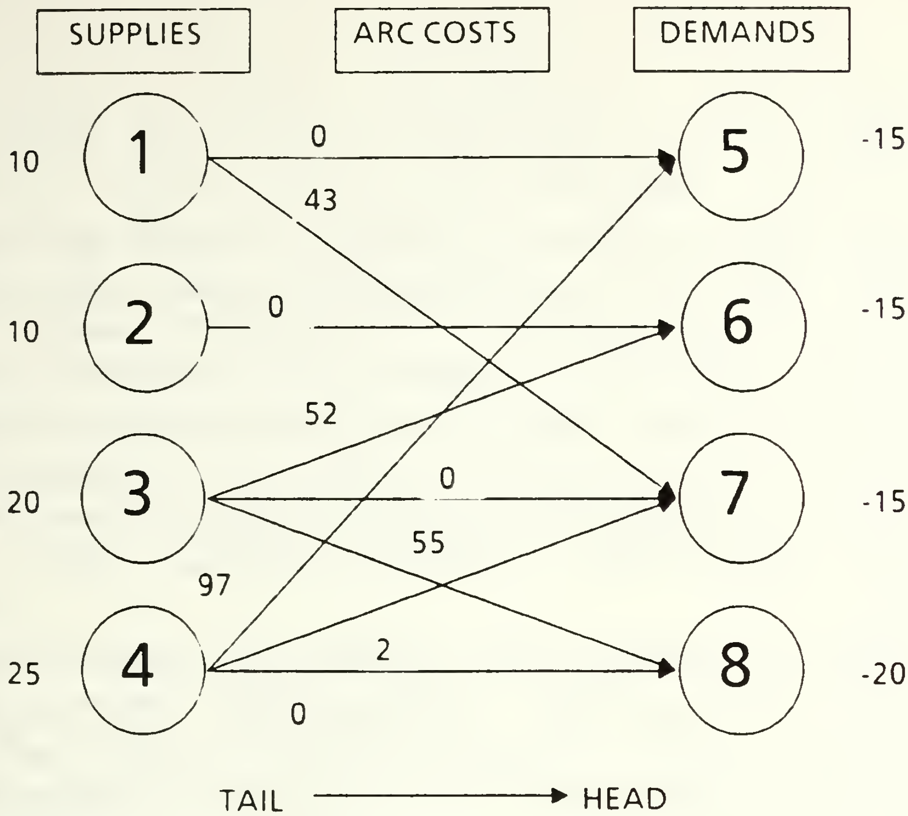
there are major changes in the future, most of the computer code will not need modification. Modular software design tends to increase CPU time, but since GNETX bears the major burden of the solving operation, the time increase compared to a non-modular model is not substantial.

Prior to running the completed final model, extensive testing was conducted to validate the cost function derivation, the arc generation and the resulting assignments. The results of this implementation are included at the end of this chapter.

B. ARC GENERATION

In considering any network model it is conceptually easier to describe arcs in a double subscript notation corresponding to the head and tail of the arc [Refs. 1 and 2]. This implies an inefficient matrix data structure for large scale problems. Efficient algorithms use a condensed data structure, to exploit sparsity. This data also fits Marine Corps assignment logic. This logic is referred to (in network jargon) as reverse star notation [Ref. 4]. An example of a network problem coded in this format is shown in Figure 4.1.

The Marine Corps assignment process is characterized by a series of restrictive rules (listed in Chapter III) that disallow most assignments. The MOS attributes are the most restrictive attributes. For example, pilots cannot fly aircraft for which they are not qualified. Since qualification in each aircraft is differentiated by MOS, MOS substitutions are not allowed in the Pilot/Naval Flight Officer



GNET ARRAYS FOR EXAMPLE PROBLEM

	X(M)	HEAD(M)	TAIL(N)	COST(N)
1	10	1	1	0
2	10	1	4	97
3	20	1	2	0
4	25	1	3	52
5	-15	1	1	43
6	-15	3	3	0
7	-15	5	4	2
8	-20	8	3	55
9			4	0

M IS THE NODE NUMBER
N IS THE ARC NUMBER

THE HEAD ARRAY POINTS TO THE FIRST ARC TAIL IN THE TAIL ARRAY OF THE ARCS COMING INTO THE HEAD. THE HEAD ARRAY POINTS TO 1 FOR ALL THE SUPPLY NODES AS THEY HAVE NO ARCS COMING INTO THEM.

FIGURE 4.1

OCCFLD. For the ground OCCFLD's MOS substitutions are allowed only inside the OCCFLD. Thus, the majority of assignments are made where the PMOS or an AMOS of the individual officer exactly matches the BMOS of the billet. Furthermore, there are many grade substitutions that are disallowed and sex and officer type will further restrict allowable assignments. Finally, during mobilization travel distance can be a restricting factor for SPF1 and SPF3 billets.

Out of a possible 900 million potential reassignments in a mobilization model only 2 million are feasible in practice. By aggregating the officers and billets according to attributes, the actual number of possible assignment choices from supply to demand nodes can be reduced to approximately 500 thousand.

Arc generation exploits sparsity in that the Marine Corps will not assign someone outside his occupation field (OCCFLD) unless he is specifically being trained in a new occupation. After the arc generator selects a demand node it only needs to consider supply nodes that have an appropriate PMOS or AMOS (i.e., one from the BMOS's OCCFLD). By creating arrays (during the data input phase) that mark the beginning of each new OCCFLD in the three supply files, the search time for legitimate arc matches in the supply files was reduced fifty fold.

The iterative process for arc generation is listed below:

1. Identify next demand node for filling.
2. Strip off the first two digits of the BMOS which is the demand node's OCCFLD.

3. Read down the OCCFLD name array and match the demand OCCFLD to the OCCFLD name that is the same.
4. Once the match is made, identify the start point of the OCCFLDs in the supply arrays. They are found in the matching element numbers of the supply pointer arrays.
5. Identify the stop points of the supply search as one element less than the next OCCFLD's start point.
6. For each supply node from start point to stop point do:
   a. Check the supply node for BSEX and OT restrictions. If a restriction applies, go to the next supply node.
   b. Compare the PMOS or an AMOS to BMOS. If they match or correspond to an allowable substitution, generate a cost. Otherwise, go to the next supply node.
   c. Compare GR to BGR. If they match or correspond to an allowable substitution, generate a cost. Otherwise, go to the next supply node.
   d. Compare CCC to BCCC. If they match or correspond to an allowable travel distance generate a cost. Otherwise, go to the next supply node.
   e. The arc is now allowable. Sum up the incremental costs to give the arc cost.
   f. If not at the last supply node look at the next supply node in the PMOS list.

12. Iterate steps 6a. through 6f. for the AMOS1 and AMOS2 supply node lists, if this is admissable. Allowable arcs are drawn from the master PMOS-ordered supply node list as both the AMOS1 and AMOS2 supply node files carry pointers back to the PMOS-ordered supply node file.

The MOS - GR combination fill file is used to further define how much searching in the three supply files is done as well as in cutting down the number of arcs created in arc generation. If a demand node corresponds to a MOS - GR combination which is in excess, then secondary MOS's (AMOS1 and AMOS2) are disregarded. This skipping is particularly useful when matching for the generalized officer billets. Most supply nodes are in the "short" category. Since this model does not assign officers in "short" MOS - GR supply nodes to generalized billet nodes, a sizeable reduction in arc generation is made.

C. ARC GENERATION - GENERALIZED BILLETS

Generalized billet nodes automatically have a larger selection of allowable supply nodes to choose from since generalized billets do not differentiate by MOS. Thus, most allowable arcs will not be used in the optimal solution. This model uses tighter tolerances on allowable moving distance to cut out these unused allowable arcs. Using tighter distance tolerance for generalized billets helps the optimizer find the best assignments faster.

When the allowable distance traveled was reduced for the generalized billet arc creation segment of the program, model solution time was decreased. The number

of arcs was reduced from about thirty thousand to about ten thousand per subproblem. The objective function values were unaffected. Thus, this restriction also optimized the original problem.

D. ARC GENERATION - BMOS IS NOT A PMOS

To exploit the sparsity in the mobilization problem, the implementation of the model orders the supply lists primarily by the officer MOS attributes (PMOS, AMOS1 and AMOS2). The majority of Marine officers are not qualified in AMOS's. Additionally, many of the supply nodes that do carry AMOS attributes have AMOS's of the type that cannot be attributed as a PMOS.

As mentioned in chapter II, there are approximately thirty BMOS's that officers may carry only as AMOS's. This model immediately bypasses searching the PMOS-ordered supply list if the demand node's BMOS is carried by officers only as an AMOS. This is accomplished by looking at the present and next OCCFLD pointers. If the pointers are the same this means there are no supply nodes matching the BMOS. The PMOS search is bypassed and the AMOS searches commence. This achieves a significant time savings in the search process whenever a demand node's BMOS is carried by officers only as an AMOS.

E. COST GENERATION

The cost for each admissable arc is determined by a composite cost function. This cost function considers the relative worth of filling a billet with an MOS substitution or a GR substitution as compared to the

worth of a perfect fit. The officer's travel distance to a particular billet is also considered, weighted and added to any other incremental costs for that particular arc. In the rare case where more than one substitution is allowed both substitution costs are added. Additionally, a penalty is incurred for utilizing retired officers in the SPF5 subproblem.

As discussed, two additional nodes are added to the model. The additional supply node named CLONEMAKER does exactly what its name implies. CLONEMAKER supplies any type officer to any billet but at a cost much greater than filling that billet with an officer who has allowable MOS, GR or OT substitutions. CLONEMAKER is given a supply of officers equal to the total demand of billets in the Marine Corps. The additional demand node named UNUSED also does exactly what its name implies. Officers that are not used in the first subproblem are passed out of the subproblem and then considered for assignments in following subproblems. After the last run regular and reserve officers assigned to UNUSED are available for assignment to East and West Coast replacement pools.

F. COST CODE RESOLUTION

Although distance is a good discriminating factor in the creation of high-resolution costs there is still the possibility of creating a fair number of arcs that have the same cost coefficient. This is particularly true in the case where there is a perfect fit and no travel is required and in the case where arcs are run from the artificial supply CLONEMAKER to all billets. A large number of cost ties is called in network terminology massive dual degeneracy and must be resolved by use of tie-breaking rules.

The monitors (assignment officers) have two rules-of-thumb for a tie. The first is that it is slightly more important to fill demand nodes with a smaller demand compared to demand nodes with a larger demand. Thus the cost of using CLONEMAKER can be weighted by the demand sizes.

The second rule is that if a shortfall of officers will be incurred it is preferable that like units with large demands share the shortfall equally. This problem occurs so rarely we do nothing to avoid it. However, multiple upper-bounded arcs could be generated from CLONEMAKER to supply each large demand where the additional arcs would incrementally cost more to use. Resolution would improve but at the probable cost of increasing model run time.

Previously, officers were generally not considered for assignments on the basis of their AMOS's except for billets that require postgraduate education. However, now that officers will have their AMOS's considered in mobilization, a thumb-rule preference for filling a billet via a PMOS-derived arc versus an AMOS-derived arc is made.

G. SOLVER INTERFACE

The author chose to use GNETX (the subroutine variant of GNET) which was copyrighted by Bradley, Brown and Graves in 1975 [Ref. 4] and which utilizes a highly specialized variant of the primal revised simplex algorithm with upper bounding.

Since GNETX is utilized as a black box subroutine, the only necessary interface to GNETX is simply to provide it a transportation problem set up in proper reverse star format. In addition, GNETX allows a tremendous amount of fine tuning for all variations of

transsshipment problems and the transportation problem considered here. These tuning parameters can be altered in the call statement, but as tuning GNETX is beyond the scope of this paper, the tuning issue is not broached. At present, the computer program allows GNETX to use the default setting of the tuning parameters. Further research will be conducted to identify the proper tuning parameters for the mobilization problem. Another future refinement will be to alter the mode in which GNETX is started. There are three possibilities: cold start, warm start and hot start. In the cold start mode, GNETX is forced to solve each subproblem starting with all zero flows, i.e., no assignments initially. The cold start mode is the easiest to implement. In the warm start mode, GNETX is given a list of initial assignments, preferably good ones, which are introduced into a trial solution, which is then optimized. A good assignment choice could be defined in this model as simply keeping an officer in his presently assigned billet. The great majority of officers will either remain in the same billet or go to billets with similar attributes to their own attributes. Warm starting GNETX yields quicker solution times. The hot start mode, which is quickest in solving, requires highly detailed network information and is the hardest to implement. All three modes are compatible with the model, but only the cold start mode has been used to date.

H. COMPUTATIONAL RESULTS

The new model MCMAM/GNET, is significantly faster than the previous model, OSGM. All preprocessing through SAS and the actual model runs were accomplished on the Naval Postgraduate School's IBM 3033AP mainframe

during July of 1987. The FY87 WASR and the DEC86 OSF were the raw input files for this model run's output. The OSGM was itself run in December of 1986 on these data sets. The comparisons in this section are based on those runs.

From start to finish the SAS preprocessing used less than thirty minutes of CPU time. The model itself was run under default GNETX tuning settings and the cold start mode. From start to finish through all three subproblems, the model took just over thirty minutes of CPU time. GNETX used twenty of those minutes. Given a good warm or hot start, it is hoped this time will become less than five minutes. The time results are significant in that it is now possible for many mobilization scenarios to be run in the space of a single day.

MCMAM/GNET yielded significant improvements in mobilization assignment quality as measured by fill and fit. MCMAM/GNET filled up the Marine Corps to 94% when measured against the WASR. The OSGM fill results on the same data sets measured against the WASR was 88%. This amounts to a difference of approximately twelve hundred officers when mobilizing a force of twenty thousand officers. Closer analysis of the billets left unfilled by MCMAM/GNET showed that the majority of these billets were in recently created MOS's such as the F/A-18 Pilot MOS and the Light Armored Vehicle Officer MOS.

Fit is viewed differently in MCMAM as compared to the OSGM, thus a direct comparison of fit is impossible. MCMAM utilized tighter substitution requirements for SPL1 and SPL3 billets. MOS substitutions in the SPL1 subproblem were not allowed at all, while in the SPL3 subproblem MOS substitutions were restricted inside the OCCFLD's though not allowed

for aviators. Additional mileage restrictions which are disregarded in the OSGM also tightened all the subproblems considerably.

Savings in movement costs probably occurred because movements were explicitly modeled and many longer distance moves were simply forbidden. However, these savings were not documented since the OSGM output does not include personnel flows.

Turbulence improvements also probably occurred since they were explicitly considered by modeling movement costs and AMOS's. Again no comparison can be made to the OSGM as it does not model turbulence.

Bringing mobilization in house to the Marine Corps will possibly yield a substantial cost savings even when considering the added expense of maintaining this model. The variable expense of utilizing a vendor's computer, the fixed expense of maintaining the OSGM out of house and the lack of utilizing sunk costs at the Marine Corps's mainframe computer at Quantico are all potential savings.

V. CONCLUSIONS AND RECOMMENDATIONS

In this thesis the Marine Corps officer assignment process during mobilization is modeled as a sequence of three transportation network models. Supply and demand nodes are modeled by discriminating attributes of officers and billets. Allowable assignments and their weighted assignment preferences are modeled as the arcs and arc costs. The costs are determined by the utility comparisons of MOS, GR and CCC attributes of the officers and billets. Additional penalties are added for using retired officers and allowances are made for modeling what are considered to be rules of thumb that the monitors use in the assignment process.

A. CONCLUSIONS

Although more work is needed, results do look promising for operationally implementing an optimization system to generate officer assignments during mobilization.

Normally when improving any model's output in quality, sacrifices in computation speed are made. However, this model shows that by combining Marine Corps assignment intuition in a generalized fashion with network optimization, improvements in assignment quality and computation speed are simultaneously achievable. This model also offers an enhanced multi-scenario capability to the decision maker.

By combining improvements in response time, fill of billets, fit of billets, movement costs, turbulence, scenario development and analysis turnaround time, a strategic improvement in mobilization is offered to the Marine Corps. Poor assignments in mobilization are not

rectified as easily as in peacetime. Thus, by giving the decision maker more time to analyze several mobilization scenarios (each of improved quality) costly assignment mistakes are avoided and better assignments are realized.

Improved assignment decision making directly improves individual unit performance. Units are in better condition and are able to deploy sooner.

B. RECOMMENDATIONS

More detailed model statistics need to be generated to validate the utility function for the users at HQMC and to completely realize the assignment improvements documented in this thesis. Fill, fit, movement cost and turbulence statistics broken down by at least MOS and grade must be derived. Continued effort in this area is being conducted by ongoing research and development. In addition, there is a need to make the rules file more dynamic so that HQMC can more easily alter the allowable arc and arc cost creation.

Once these improved statistics are derived and incorporated in the computer programming, the following improvements in mobilization planning can occur in the following general areas:

1. Determination of potential officer shortages in wartime by MOS and grade.
2. Determination of the resulting effects on unit combat preparation by altering fill, fit, movement cost and turbulence objectives.
3. Determination of dollar expenditures for moving officers dependent on time requirements.
4. Validation to Congress of the need for moving expenses and determination of how much is needed.

5. Determination of the impact of mobilization upon air, rail and road networks.
6. Determination of the needed end strengths of women officers by MOS and grade.
7. Determination of the impact on national defense by removing specific groups of reserve officers from the civilian sector.

The peacetime assignment process can benefit from the results of the research conducted for the mobilization assignment process. By incorporating existing Marine Corps orders, assignment logic and rules of thumb with optimization principles, the peacetime assignment process can be improved. Instead of hampering the monitors, a similar peacetime system could be built to accurately reflect the Marine Corp's ever changing assignment criteria and augment the monitor's intuitive assignment insight. In addition, Congressional guidance could be more easily followed (or debated) when the Permanent Change of Station (moving expenses) budget is under review. Last, but not least it would also save a substantial amount of money.

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